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71 Applicant: **ASEA BROWN BOVERI AB**

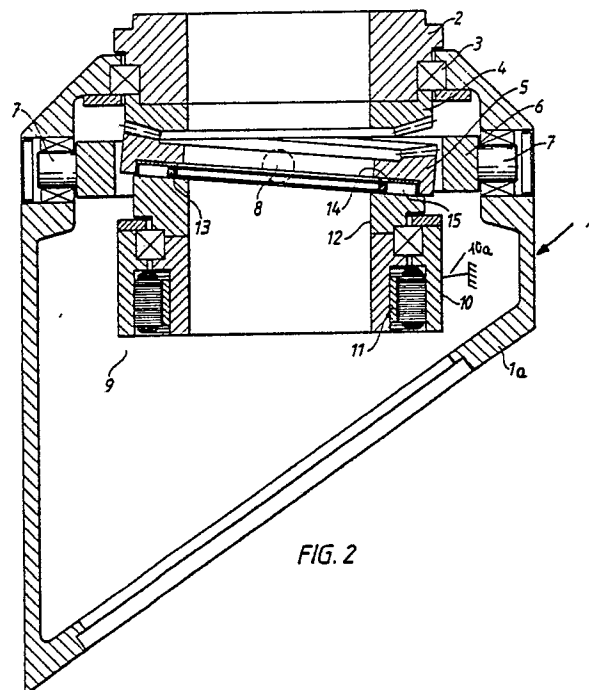
S-721 83 Västerås(SE)

72 Inventor: **Dahlquist, Hakan**
Klockartorpsgatan 30 C
S-723 44 Västerås(SE)

74 Representative: **Boecker, Joachim, Dr.-Ing.**
Rathenauplatz 2-8
D-6000 Frankfurt a.M. 1(DE)

54 **Robot wrist.**

57 Robot wrist comprising a plurality of mutually rotatable tubular parts arranged in series with each other and a tubular member (2), such as an tool attachment, said member (2) being rotatable mounted to one (1) of said parts and, via a tubular gear, being driven by a separate motor. According to the invention said motor (10,11) has a tubular rotor (11) which, along with said tubular gear (4,5,15,12), is concentrically arranged with said tubular member (2) to form a channel for supply and/or communication means. The robot wrist exhibits a great orientation capacity in space while having at the same time a relatively small diameter, which enables the insertion of the part (1) into confined spaces.



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Robot wrist

The invention relates to a robot wrist according to the precharacterising part of claim 1.

Modern engineering industry places increasingly heavy demands on the orientation capacity of the arm and wrist of a robot. A plurality of different arm and wrist designs are known which enable to operate a tool in different positions within a working area. In order for the arm and the wrist to be capable of being operated in the desired manner, a plurality of axes and gears rotating inside the arm and the wrist, and sometimes also separate motors, are additionally required. These units are relatively space-demanding and if, in addition, for example, the wrist is to accommodate hydraulic and/or electric cables for the supply of power to the tool carried by the wrist, it may be necessary to construct a relatively thick wrist. This, however, reduces the ability of the robot to operate in confined spaces. In prior art devices, for example according to US-A-4,690,012, the drive motor for the tool attachment is a fully normal motor mounted at the side of the tubular tool attachment which is driven via a gear. The gear may also to a certain extent occupy lateral space.

The invention aims at developing a robot wrist which, on the one hand, is of relatively slim design and, on the other hand, provides ample through-going inner space to allow the passage of supply and/or communication means through the wrist.

To achieve this aim the invention suggests a robot wrist according to the introductory part of claim 1, which is characterized by the features of the characterizing part of claim 1.

Further developments of the invention are characterized by the features of the additional claims.

According to the invention the gear and the motor are built together to form a tubular motor-gear package, which is arranged concentrically with the member, for example a tool attachment, driven by it. Both, the gear wheels and the rotor, are made tubular in order to create a channel for supply and/or communication means. Such means may comprise, for example, hydraulic and/or electric cables, glass fibre cables or mere light or laser light beams. At a given diameter of the channel, the outer diameter of the wrist will be smaller than if the motor and/or the gear were arranged adjacent to the channel.

By way of example, the invention will now be described in greater detail with reference to the accompanying drawings showing in

Figure 1 a robot with a robot wrist according to the invention,

Figure 2 a section through the wrist joint 1 in Figure 1 in enlarged scale to show the details of one embodiment of the invention.

In the embodiment of Figure 1, 1 designates the outer joint or part of a robot wrist. In this part 1, which is shown in more detail in Figure 2, a tubular tool attachment 2 is rotatably journaled by means of a bearing 3. An annular bevel gear wheel 4 is concentrically fixed to the tool attachment 3. A similarly annular bevel gear wheel 5, meshing with the gear wheel 4, is non-rotatably fixed in relation to the housing 1a of the part 1 by means of a cardanic suspension. The cardanic suspension comprises an outer ring 6 which is tiltably journaled in the outer part 1 by means of the pins 7. Inside this outer ring 6, the annular gear wheel 5, in its turn, is tiltably suspended from the ring 6 by means of the pins 8, the axis of the pins 8 subtending at an angle of 90 degrees with the axis of the pins 7. A tubular motor 9 is concentrically arranged in relation to the bevel gear pair 4,5 and the tool attachment 2. The stator 10 of the motor 9 is fixedly joined to the housing 1a of part 1, as symbolically indicated at 10a, whereas the tubular rotor 11 is provided with a similarly tubular shaft 12, the end 13 of which, facing the gear wheel 5, is obliquely shaped. On its side facing the end 13 of the shaft 12, the gear wheel 5 is provided with a turned recess in which a plane washer 14 is placed. A needle roller thrust bearing 15 is inserted into the recess and between the washer 14 and the end 13 of the shaft 12.

When the rotor 11 rotates, its end 13 will, without any major friction, roll off against the gear wheel 5 which, as stated above, does not rotate in relation to the housing 1a and hence the stator 10. Since the end 13 of shaft 12 is oblique and the gear wheel 5 is cardanically suspended, the gear wheel 5 will perform a wobbling movement, whereby the contact point between the gear wheels 4 and 5 travels around their circumference. If it is assumed that the number of teeth on wheel 5 is 100 and on wheel 4 is 98, then the gear wheel 5, during a full revolution of the contact point between the gear wheels, will mesh with 100 teeth in the wheel 4, which thus performs a rotation in the opposite direction as the rotor 11 corresponding to only two teeth. In this way, a reduction of $2:100 = 1:50$ is obtained. The direction of rotation of the gear wheel 4 can be reversed by giving the gear wheel 5 the lower number of teeth, for example 98, and by giving the gear wheel 4 100 teeth.

In summary, the invention results in a tubular motor-gear package without backlash, which is ex-

cellently well suited as drive member for a tool holder mounted to a robot arm, provided that said motor-gear package and tool holder are arranged concentrically in relation to each other, enabling the construction of a thinner robot wrist than prior art robot wrist of similar design. 5

The part of the robot wrist to which the above described motor-gear package is mounted, need not be the outermost joint of the robot wrist as with the embodiment described above. For example, 10 the tool attachment member 2 may be replaced by a member forming a further part of the robot wrist. This member could be used for further orientation purposes of the wrist. The member 2 could also take the form of an elongated tube to increase the overall length of the robot arm. The robot tool holder could then, for example, be attached to the wrist member 2. 15

The hollow channel obtained by the invention throughout the robot wrist can be used, for example, to accommodate electric or hydraulic cables to supply energy or other matter to the working area or to allow the passage of communication means, such a laser light beam. 20

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Claims

1. Robot wrist comprising a plurality of mutually rotatable tubular parts arranged in series with each other and a tubular member (2), such as an attachment for tools or other elements of the robot, said member (2) being rotatably mounted to one (1) of said parts and, via a tubular gear, being driven by a separate motor, **characterized** in that said motor (10,11) has a tubular rotor (11) and that said rotor and said tubular gear (4,5,15,12) are concentrically arranged with said tubular member (2) to form a channel for supply and/or communication means. 30 35 40

2. Robot wrist according to claim 1, **characterized** in that the gear (4,5,15,12) consists of a so-called nutational gear.

3. Robot wrist according to claim 1 or 2, **characterized** in that a first annular gear wheel (4) is fixed to said member (2) while a second gear wheel (5) is cardanically suspended from the housing (1a) of said part (1) such that it is prevented from rotating about its drive axis relative to the housing (1a). 45 50

4. Robot wrist according to any of the preceding claims, **characterized** in that said part (1) is the outermost joint of the robot wrist and said member (2) the tool attachment of the wrist. 55

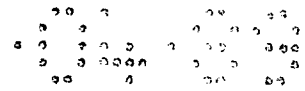
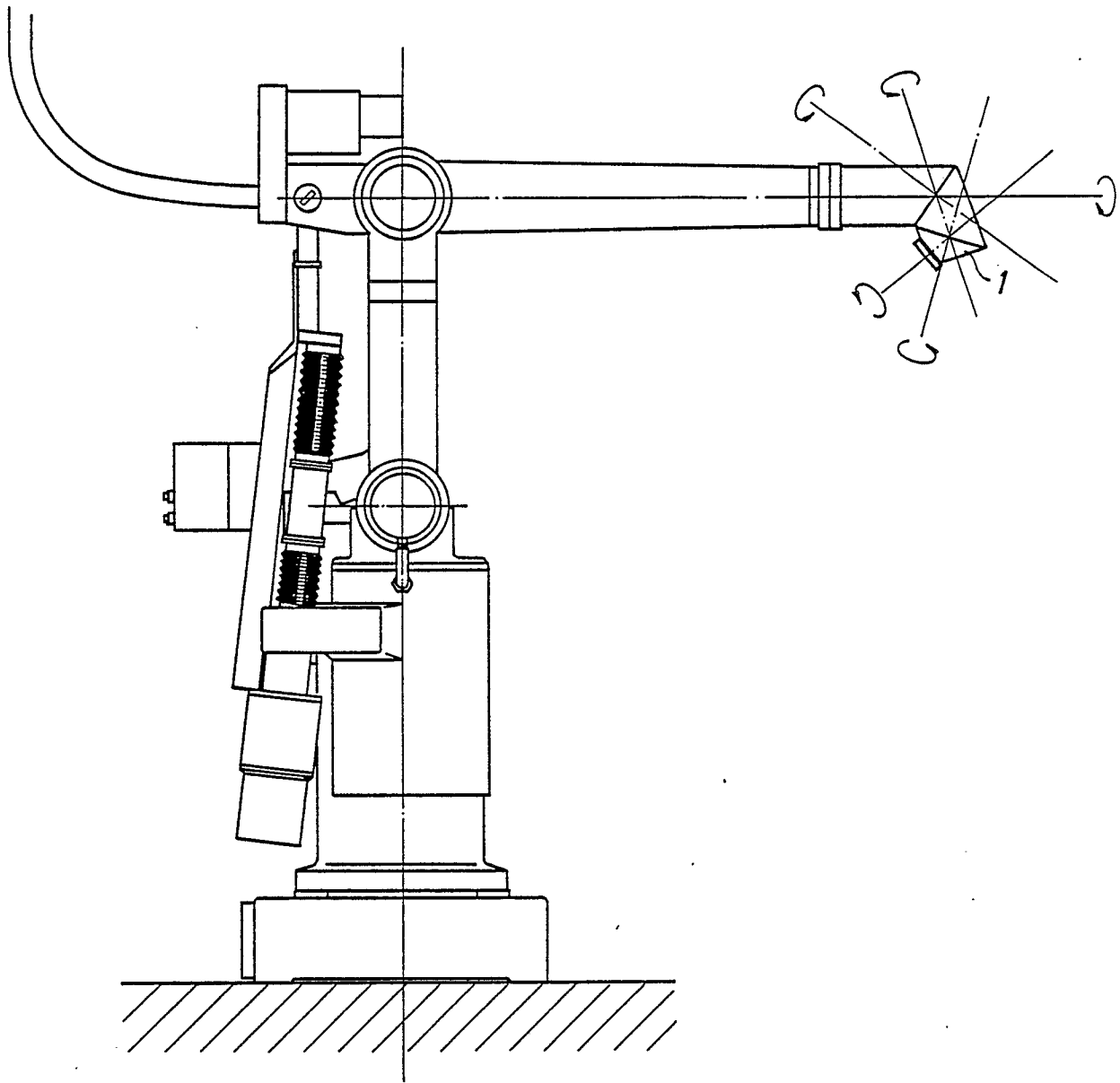
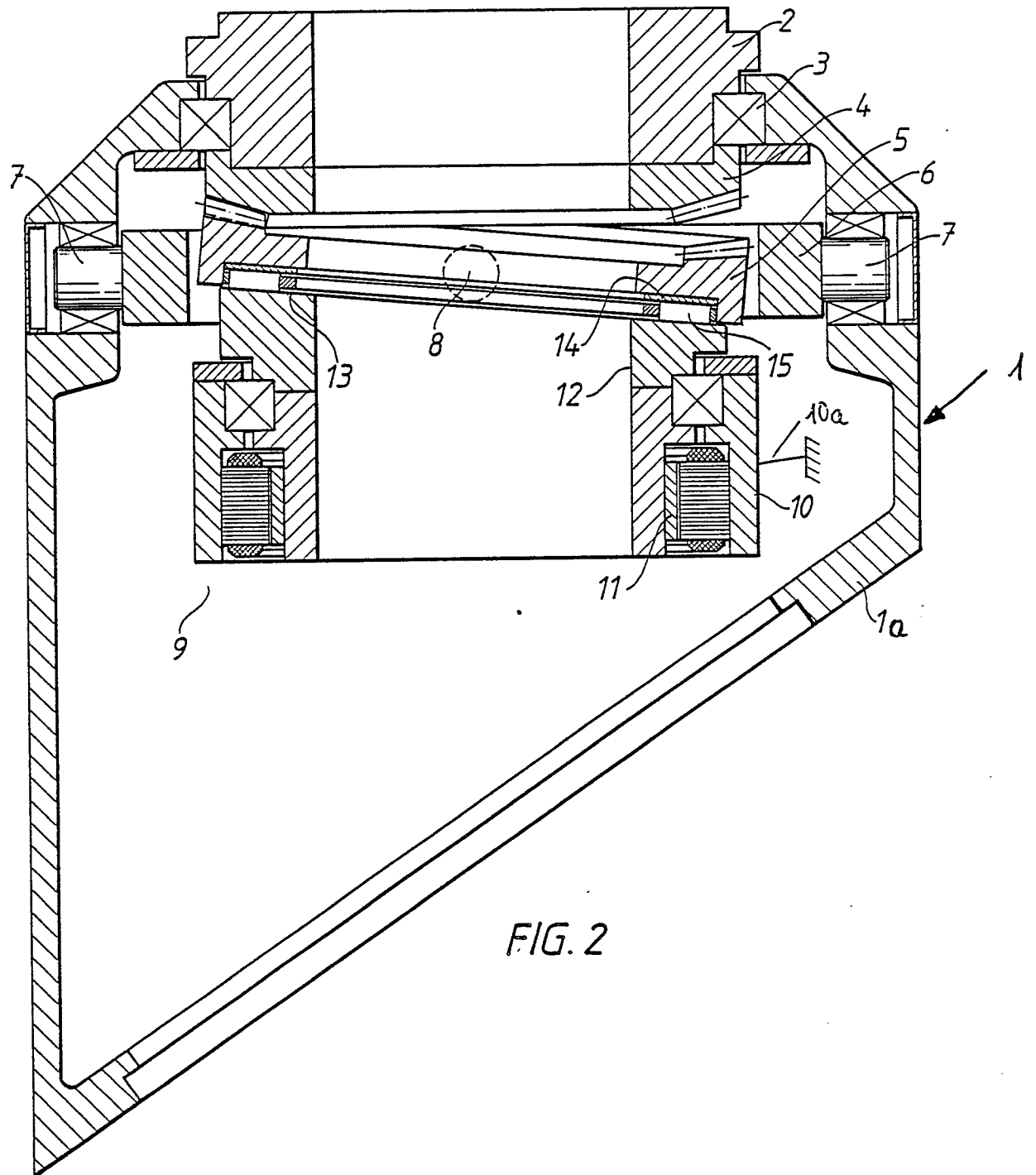


FIG. 1







DOCUMENTS CONSIDERED TO BE RELEVANT			
Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int. Cl. 4)
A	DE-A-3 601 456 (CMF ROBOTICS CORP)		B 25 J 17/02

A	GB-A-2 182 017 (CHAMPION SPARK PLUG COMP)		

A	US-A-4 690 012 (ASEA AB)		

			TECHNICAL FIELDS SEARCHED (Int. Cl. 4)
			B 25 J F 16 H 901
The present search report has been drawn up for all claims			
Place of search STOCKHOLM		Date of completion of the search 18-07-1989	Examiner FORSSÉN C.
CATEGORY OF CITED DOCUMENTS		T : theory or principle underlying the invention E : earlier patent document, but published on, or after the filing date D : document cited in the application L : document cited for other reasons & : member of the same patent family, corresponding document	
X : particularly relevant if taken alone Y : particularly relevant if combined with another document of the same category A : technological background O : non-written disclosure P : intermediate document			